Paul-Konstantin Oehlmann

Theory Research Group: Wilfried Buchmüller & Jan Louis

Personal Life

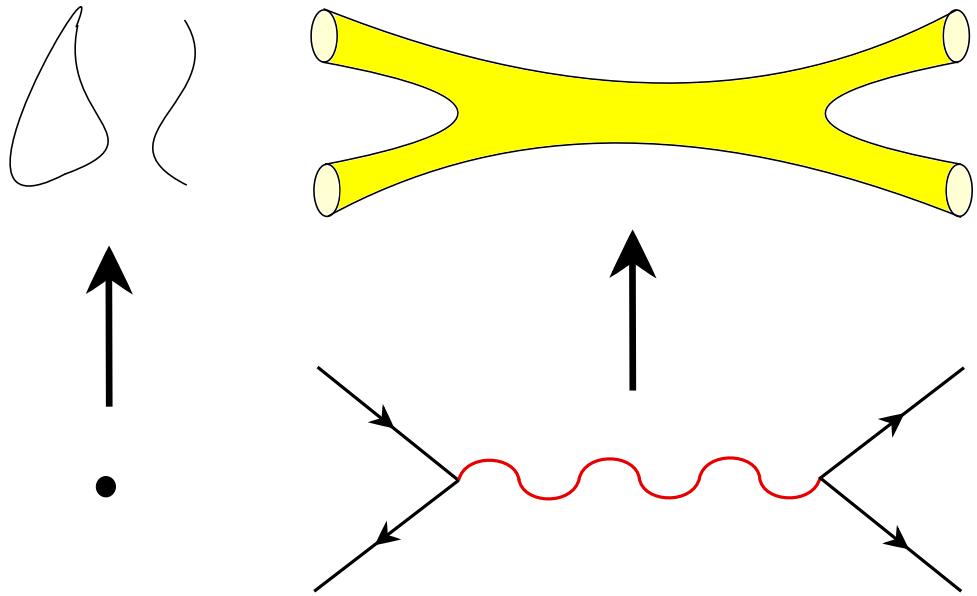
- Born: 1985 in Leipzig
- School: Dortmund/Neuss
- non-physics interests: Martial Arts, Running, Whisky

Academic Carrier

- Bachelor, Master, PhD: Bonn University with Hans Peter Nilles
- Visiting Researcher: KIAS (Seoul) Virginia Tech
- 1. Postdoc: DESY, until '17
- 2. Postdoc: Virginia Tech until '19

String Theories

- String Theory Idea: extend point like particles by one dimension more!

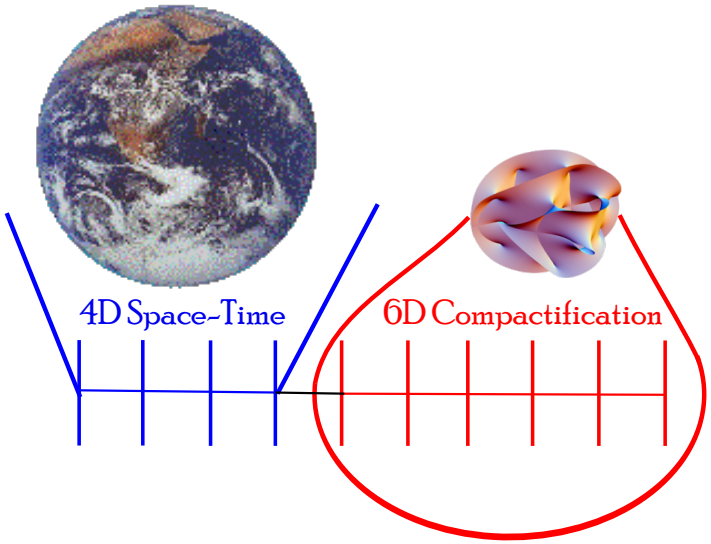


A bunch of consequences

Assuming (Quantized) Strings as fundamental objects is highly constraining:

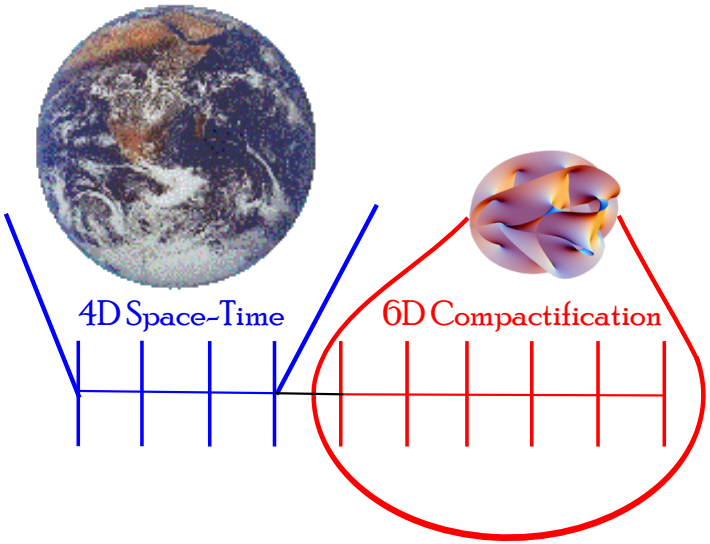
- Must have a **Graviton** in its massless spectrum
- Space-time must be 9(space)+1(time) dimensional
  $\rightarrow$ Make extra dimension compact and small

Compactification



Compactification has a highly non-trivial **impact** on 4D **Physics**

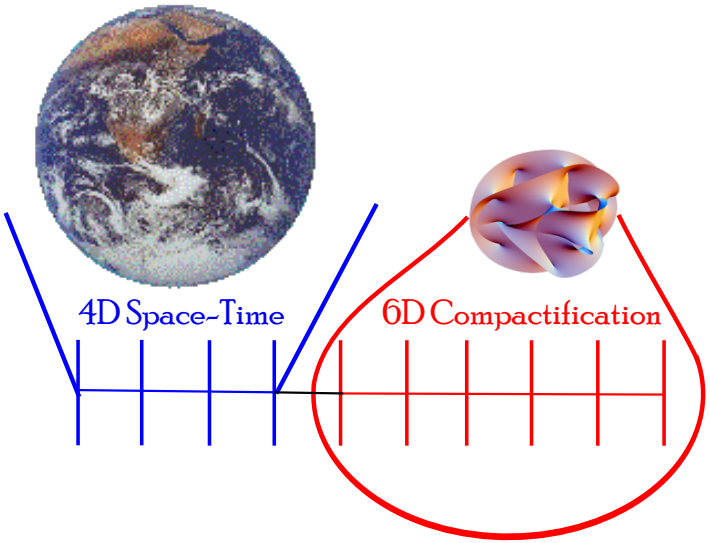
Compactification



Dictionary of Physics and Geometry

- Like **harmonics** of a Cello, string state **probe shape of internal geometry**

Compactification



Dictionary of Physics and Geometry

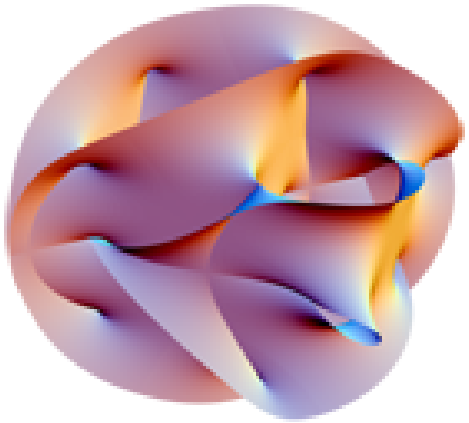
- Like **harmonics** of a Cello, string state **probe shape of internal geometry**
- **Mathematical** properties of the **compact** internal space
  $\leftrightarrow$ **Physical properties** of the four **non-compact** Dimensions

My Research Interests

Given, that we have a theory, that includes quantized gravity, we should explore its structures and see if we can connect it to our world

1. String Compactifications
   - F-theory
     - Gauge Symmetries: Abelian Symmetries, Discrete Symmetries . . .
     - Global Compactifications: Moduli, Fluxes
   - Heterotic String and Gauged Linear Sigma Models
     - Discrete (gauged)-Symmetries, R-Symmetries
     - Landau-Ginzburg Phase, Mirror Symmetry
2. String Phenomenology
   - Grand Unified Models from Heterotic String on Orbifolds
   - Standard Model and GUTs in F-theory flux compactifications

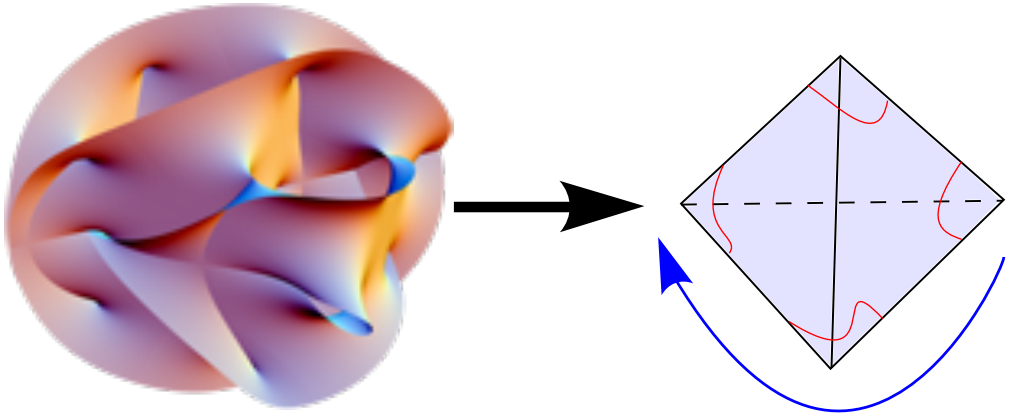
Symmetries $\leftrightarrow$ Geometry in Heterotic String



Geometric Transitions and Higgs Effect

1. Start with **Smooth Space** compute the **harmonic** string states

Symmetries $\leftrightarrow$ Geometry in Heterotic String

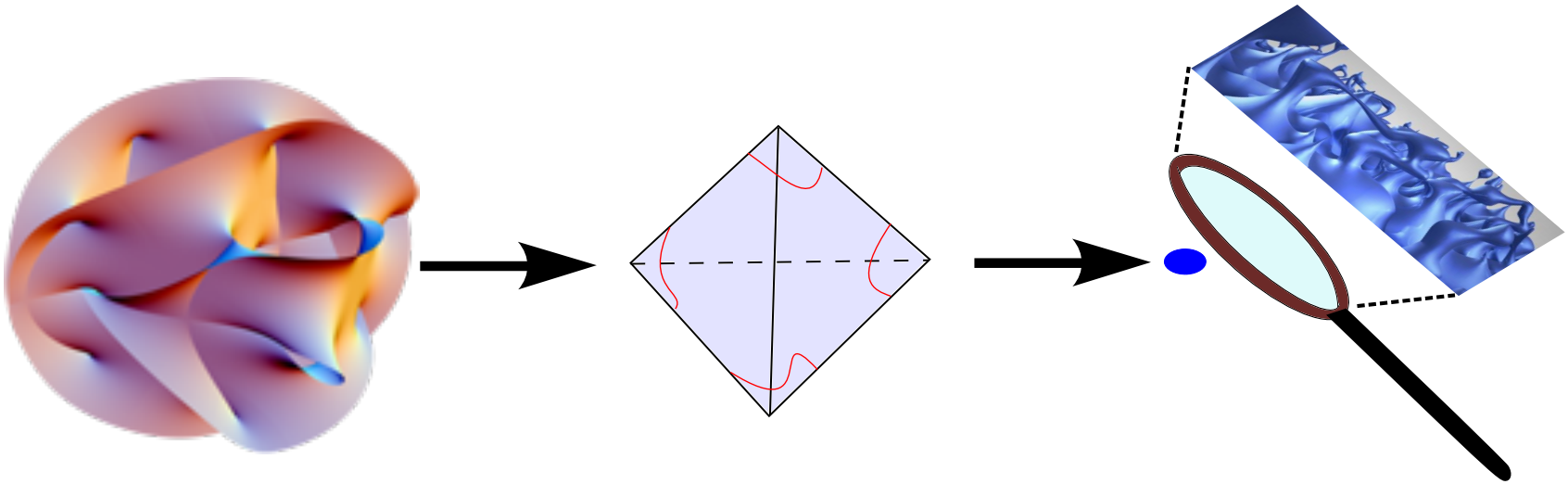


Geometric Transitions and Higgs Effect

1. Start with **Smooth Space** compute the **harmonic** string states
2. • **Geometric operation**: Push **curvature** to singular points (**Orbifold**)
   • **Physics Response**: more string states, more symmetries
   $\rightarrow$ un-higgsing (such as Electro-Weak Unification)

   $\rightarrow$ **Discrete rotations**: Flavor- and R-symmetries usefull Pheno applications

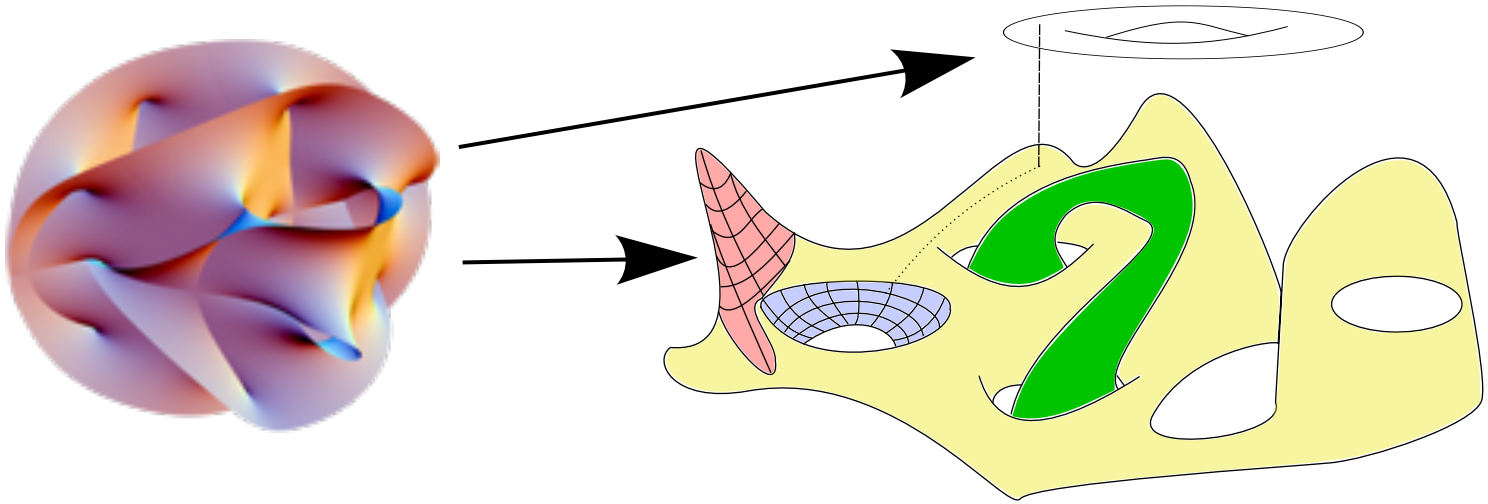
Symmetries $\leftrightarrow$ Geometry in Heterotic String



Geometric Transitions and Higgs Effect

1. Start with **Smooth Space** compute the **harmonic** string states
2. • **Geometric operation**: Push **curvature** to singular points (**Orbifold**)
   • **Physics Response**: more string states, more symmetries
   $\rightarrow$ un-higgsing (such as Electro-Weak Unification)
3. • **Geometric operation**: Push full space to singular point
   • **Physics Response** another un-higgsing but (classical) geometry screwed up

F-theory Compactifications



F-theory Idea

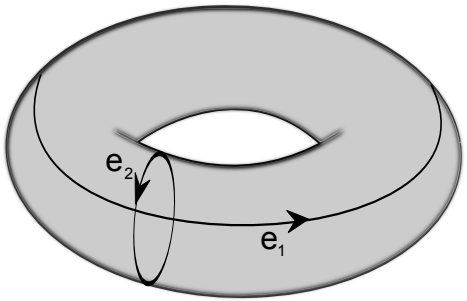
Take the **geometrization** of physics even **more serious**

- Make the string **coupling constant** g a geometric property:

$$g^{-1} = \mathrm{Im}(\tau) \text{ with } \tau = \frac{e_2}{e_1}$$

- τ being the complex *shape* modulus of the torus

F-theory Compactifications



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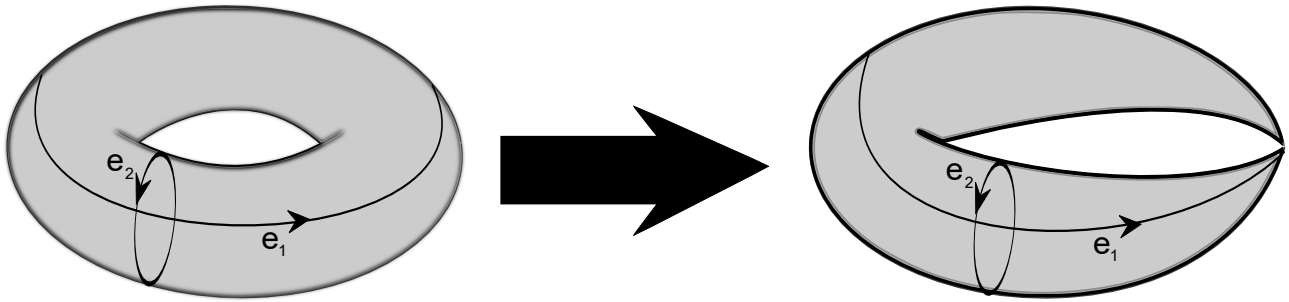

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- Make the string **coupling constant** g a geometric property:

$$g^{-1} = \mathrm{Im}(\tau) \text{ with } \tau = \frac{e_2}{e_1}$$

- τ being the complex *shape* modulus of the torus
- $\tau \to i\infty$ singular torus, strong coupling, enhanced gauge symmetries

Summary

String Theory and String Geometries

Compelling framework to geometrize physics and gravity in a UV complete way

- **Mathematics:** Learn to understand the dictionary
- **Physics:** To which degree can we **construct models of particle physics** from string theory? How to we obtain the standard model?

String Theory beyond Geometry

String theory provides a rich environment to study

- **Dualities:** Same Physics encoded in completely different geometries
- Spaces that completely **screw** up our notion of **geometry**

Thank You Very Much!